

DERIVATIVES OF MONOSACCHARIDES AS CELL ADHESION

5

INHIBITORS

FIELD OF THE INVENTION

This invention relates generally to compounds and processes for
10 synthesizing derivatives of 2-3-O-isopropylidene- α -L-xylo-2-hexulofuranosonic
acid. The compounds of this invention are useful, inter-alia, for the inhibition
and prevention of cell adhesion and cell adhesion-mediated pathologies,
including inflammatory and autoimmune diseases, such as bronchial asthma,
rheumatoid arthritis, type I diabetes, multiple sclerosis, allograft rejection and
15 psoriasis. This invention also relates to pharmacological compositions
containing derivatives of 2-3-O-isopropylidene- α -L-xylo-2-hexulofuranosonic
acid and the methods of treating such pathologies as listed above.

BACKGROUND OF THE INVENTION

20 Cell adhesion is a process by which cells associate with each other
and migrate towards a specific target localized within the extracellular matrix.
Specialized molecules, called cell adhesion molecules (CAMs), mediate these
reactions. CAMs have been demonstrated to participate in various cell-cell,
cell-extracellular matrix, and platelet-platelet interactions. CAMs influence the
25 leukocytes' adhesion to the vascular endothelium, their transendothelial

migration, retention at extravascular sites, and activation of T cells and eosinophils. These processes are central to the pathogenesis of inflammatory and autoimmune diseases. Therefore, CAMs are considered potential targets for treating such disorders.

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CAMs can be classified into three groups: integrins, selectins, and the immunoglobulin superfamily. Of these, integrins are the key mediators in the adhesive interactions between hemopoietic cells and their microenvironment. They are comprised of alpha-beta heterodimers and integrate signals from the
10 outside to the inside of cells, and vice versa. Integrins can be classified on the basis of the beta subunits they contain. For example, the beta-1 subfamily contains beta-1 subunit noncovalently linked to one of the 10 different alpha subunits.

15 The alpha-4 beta-1 integrin, also known as VLA₄ (very late activation antigen 4), is a member of the beta-1 integrin family and comprises alpha-4 and beta-1 subunits. VLA₄ interacts with two specific ligands—the vascular cell adhesion molecule (VCAM-1) and the CS1 region of the protein fibronectin. Adhesion mediated by VLA₄ is central to the process of
20 transendothelial migration of leukocytes. Ligation of VLA₄ is followed by gross rearrangement of the cytoskeleton, leading to flattening of cells along the blood vessel wall, followed by expression of specific molecules that digest the endothelial cell wall and diapedesis. Once in the extraluminal region, the interactions of VLA₄ with extracellular fibronectin play a crucial role in the
25 migration of leukocytes to the site of inflammation, T cell proliferation,

expression of cytokines and inflammatory mediators. Additionally, VLA₄ ligation provides co-stimulatory signals to the leukocytes, resulting in enhanced immunoreactivity. Thus, appropriate VLA₄ antagonists would, in theory, ameliorate the immune response through a twofold action—inhibition
5 of T cell recruitment at the site of inflammation and inhibition of co-stimulatory activation of immune cells.

In this respect, inhibitors of VLA₄ interactions have been demonstrated to exhibit beneficial therapeutic effects in several animal models of
10 inflammatory and allergic diseases, including sheep allergic asthma (Abraham et al, J. Clin. Invest. 1994;93:776); arthritis (Wahl et al, J. Clin. Invest. 1994;94:655); experimental allergic encephalomyelitis (Yednock et al, Nature (Lond), 1992;356:63 and Baron et al, J. Exp. Med. 1993;177:57); contact hypersensitivity (Chisolm et al, Eur J. Immunol. 1993;23:682); type I diabetes
15 (Yang et al, Proc. Natl. Acad. Sci. (USA) 1993;90:10494); and inflammatory bowel disease (Podolsky et al, J. Clin. Invest. 1993;92:372).

The CS1 moiety region of fibronectin involved in the interaction with VLA₄ was identified as the tripeptide Leu-Asp-Val (LDV) (Komoriya et al, J.
20 Biol. Chem. 1991;266:15075). Several peptides containing the LDV sequence were synthesized and shown to inhibit the *in vivo* interaction of VLA₄ to its ligands (Ferguson et al, Proc. Natl. Acad. Sci. (USA) 1991;88:8072; Wahl et al, J. Clin. Invest. 1994;94:655; Nowlin et al, J. Biol. Chem. 1993;268(27):20352; and PCT publication WO91/4862).

Despite these advances a need for small and specific inhibitors of VLA₄-dependent cell adhesion molecules remains. Ideally, such inhibitors are water soluble with oral efficacy. Such compounds would provide useful agents for the treatment, prevention or suppression of various inflammatory pathologies mediated by VLA₄ binding.

It is generally known that isopropylidene and benzylidene groups are the most commonly used protective groups in carbohydrate chemistry. Although both groups are introduced into a molecule under similar conditions, the location of the protection can be quite different, and this difference is directly related to the stability of each protected molecule. Since protection normally occurs under conditions that allow reversibility, the reaction proceeds until equilibrium is reached. The distribution of products at equilibrium is determined by their relative thermodynamic stabilities. In other words, these reactions are thermodynamically controlled. Benzylidene groups prefer to be part of 6-membered ring acetals, while the ketals resulting from acetonation generally are 5-membered rings. The difference is attributed to the effect of the methyl and phenyl substituents on the stability of the particular ring systems. These blocking methods are described in the U.S. Pat. Nos. 2,715,121, 4,056,322, 4,735,934, 4,996,195 and 5,010,058, the disclosures of which are incorporated herein by reference. Other blocking methods are also described in J. Carbohydr. Chem. 1985;4:227 and 1984;3:331; Methods in Carbohydr. Chem. 1962;1:107 and 1962;1:191; Can J. Chem. 1984;62:2728, 1969;47:1195, 1455, and 1970;48:1754, all incorporated herein by reference. The prior art reveals that D-glucose is blocked at the 1,2;5,6-positions with

either the isopropylidene or cyclohexylidene blocking group, leaving the 3-position open to undergo derivatization. The therapeutic activity of hexoses and their derivatives are also disclosed in some of the above-cited prior art.

The compounds of the present invention were screened for inhibitory activity in VLA₄-mediated cell adhesion assay and the classical murine hypersensitivity assay in mice. Several compounds exhibited significant inhibitory activity in both tests. The salts of these compounds could be easily solubilized in water and used in the treatment of chronic, cell adhesion-mediated, allergic, autoimmune and inflammatory disorders, such as bronchial asthma and rheumatoid arthritis. Some of the prior art describes development of peptide derivatives as cell adhesion antagonists for treatment of these diseases. However, because treatment of chronic diseases requires prolonged (mid-term to long-term) administration of drugs, the development of specific, orally available cell adhesion inhibitors would be very beneficial.

There is no example available in the prior art wherein the compounds, containing a sugar nucleus coupled with carbamate moiety, of the present invention are used as therapy for the inhibition, prevention and suppression of VLA₄-mediated cell adhesion and pathologies associated with that adhesion.

SUMMARY OF THE INVENTION

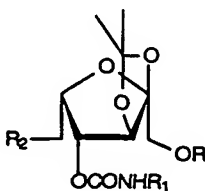
An object of the present invention is to provide a process for synthesizing a new class of compounds that exhibit significant activity as VLA₄ antagonists.

Most of the compounds described in U.S. Pat. No. 5,637,570 have shown significant anti-cancer activities and were devoid of any anti-cell adhesion activities. Therefore, the compounds of the present invention were designed and synthesized so as to enhance their anti-cell adhesion properties. It was discovered that, for a compound to be active as a cell adhesion inhibitor, it is best if the sugar has a carbamate moiety along with other functionalities.

It is a further object of this invention to provide a process for the preparation of novel carbohydrate-based water-soluble compounds that exhibit significant activity to be used as cell adhesion antagonists.

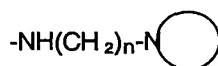
Other objects and advantages of the present invention will be set forth in the description that follows, will be in part apparent from the description, or may be learned by the practice of the invention. The objects and advantages of this invention may be realized and obtained by means of the mechanisms and combinations pointed out in the appended claims.

In order to achieve the above-mentioned objects and in accordance with one aspect of the present invention, there is provided a process for the synthesis of monosaccharide derivatives and the derivatives themselves, having the structure of Formula I:



FORMULA I

wherein R is C₁ to C₁₅ alkyl, alkene, alkyne (straight chain or branched), aryl, substituted aryl or alkylaryl, R₁ is phenyl, o-, m- or p-chlorophenyl, tolyl, methoxyphenyl or nitrophenyl and R₂ is H, pyrrolidinyl, piperidinyl, morphilinyll or hexamethyleneimino or a radical of the formula -NHR₃ wherein R₃ is C₁ to C₁₅ alkyl, alkene or alkyne (straight chain or branched) or a radical of Formula III:



FORMULA III

wherein n is a whole number up to 5 and



is a five-, six- or seven-membered heterocyclic ring containing one or more heteroatoms, and wherein preferably



is pyrrolidinyl, piperidinyl, morpholinyl or hexamethyleneimino moieties.

Preferred compounds are those wherein R₁ and R₂ are not H at the same time. Acid addition salts of the above compounds are also included in the invention.

In accordance with another aspect of the present invention there is provided a list of compounds as shown below in the description of the invention section.

In accordance with another aspect of the present invention there are provided methods of preventing, inhibiting or suppressing cell adhesion in an animal (the term animal as used herein includes humans or mammals), comprising administering to said animal, the compounds described above.

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In accordance with another aspect of the present invention there is provided a method for treating an animal suffering from bronchial asthma, rheumatoid arthritis, multiple sclerosis, type I diabetes, psoriasis, allograft rejection, and other inflammatory and/or autoimmune disorders, comprising
10 administering to said animal, the compounds described above.

In accordance with yet another aspect of the present invention there is provided a method for preventing, inhibiting or suppressing cell adhesion-associated inflammation with compounds described above.

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In accordance with a further aspect of the present invention there is provided a method for preventing, inhibiting or suppressing a cell adhesion-associated immune or autoimmune response with the compounds described above.

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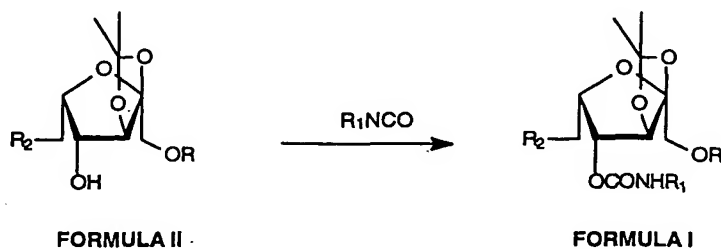
In accordance with another aspect of the present invention there is provided a method for treating or preventing a disease selected from the group consisting of asthma, arthritis, psoriasis, allograft rejection, multiple sclerosis, diabetes and inflammatory bowel disease, with the compounds as
25 described above.

The compounds of the present invention are novel and exhibit significant potency in terms of their activity, which was determined by *in vitro* VLA₄-mediated cell adhesion assay and *in vivo* mouse ear swelling test. The compounds that were found active in *in vitro* assay were tested *in vivo*. Some of the compounds of the present invention were found to be potent VLA₄ antagonists. Therefore, the present invention provides the pharmaceutical compositions for the possible treatment of bronchial asthma and other inflammatory and autoimmune disorders. In addition, the compounds of the above invention can be administered orally or parenterally.

DETAILED DESCRIPTION OF THE INVENTION

The compounds of the present invention may be prepared by techniques well-known in the art and familiar to the average synthetic organic chemist. In addition, the compounds of the present invention may be prepared by the following novel and inventive reaction sequence, which also show preferred R, R₁ and R₂ groups.

SCHEME I



2,3-O-Isopropyl-1-O-alkyl or arylalkyl-6-deoxy-6-aminosubstituted-L-xylo-2-hexulofuranose compounds of Formula II, as shown in Scheme I, are prepared according to the method described in U.S. Pat. No. 5,637,570 and are the intermediates for the synthesis of the compounds of Formula I of the present invention. Thus, the following intermediates were prepared following the process as described in U.S. Pat. No. 5,637,570:

2,3-O-isopropylidene-6-deoxy-6-hexamethyleneimino-1-O-dodecyl- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-6-deoxy-6-hexamethyleneimino-1-O-decyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-hexamethyleneimino-1-O-heptyl- α -L-xylo-2-hexulofuranose

15 2,3-O-isopropylidene-6-deoxy-6-pyrrolidinyl-1-O-dodecyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-pyrrolidinyl-1-O-decyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-pyrrolidinyl-1-O-heptyl- α -L-xylo-2-hexulofuranose

20 2,3-O-isopropylidene-6-deoxy-6-morphiliny-1-O-dodecyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-morphiliny-1-O-decyl- α -L-xylo-2-hexulofuranose

25 2,3-O-isopropylidene-6-deoxy-6-morphiliny-1-O-heptyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-piperidiny-1-O-dodecyl- α -L-xylo-2-
hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-piperidiny-1-O-decyl- α -L-xylo-2-
hexulofuranose

5 2,3-O-isopropylidene-6-deoxy-6-piperidiny-1-O-heptyl- α -L-xylo-2-
hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-ethylpyrrolidiny-1-O-dodecyl- α -L-xylo-2-
hexulofuranose

10 2,3-O-isopropylidene-6-deoxy-6-ethylpyrrolidiny-1-O-decyl- α -L-xylo-2-
hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-ethylpyrrolidiny-1-O-heptyl- α -L-xylo-2-
hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-ethylmorpholinyl-1-O-dodecyl- α -L-xylo-2-
hexulofuranose

15 2,3-O-isopropylidene-6-deoxy-6-ethylmorpholinyl-1-O-decyl- α -L-xylo-2-
hexulofuranose

2,3-O-isopropylidene-6-deoxy-6-ethylmorpholinyl-1-O-heptyl- α -L-xylo-2-
hexulofuranose.

20 Thus, the compound of Formula II is treated with an appropriate
isocyanate in a suitable solvent at low temperature, preferably at 0–10° C to
afford the compounds of Formula I of the present invention. An illustrative list
of particular compounds according to the invention and capable of being
produced by Scheme I include:

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Compound	Chemical Name
No.	
01.	2,3-O-Isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
5	02. 2,3-O-Isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
03.	2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
04.	2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
10	
05.	2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
06.	2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
15	
07.	2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
08.	2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
09.	2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
20	
10.	2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
11.	2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

12. 2,3-O-Isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
13. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
- 5 14. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
15. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
16. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
- 10 17. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
18. 2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
- 15 19. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
20. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
21. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
- 20 22. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
23. 2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

24. 2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
25. 2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
- 5 26. 2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
27. 2,3-O-Isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
28. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
- 10 29. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
30. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
- 15 31. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
32. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
33. 2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
- 20 34. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
35. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

36. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
37. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
- 5 38. 2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
39. 2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
40. 2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
- 10 41. 2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
42. 2,3-O-Isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
- 15 43. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
44. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
45. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
- 20 46. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
47. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

48. 2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
49. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 5 50. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
51. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
52. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 10 53. 2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
54. 2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 15 55. 2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
56. 2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
57. 2,3-O-Isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 20 58. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
59. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose

60. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
61. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 5 62. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
63. 2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
64. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
- 10 65. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
66. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
- 15 67. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
68. 2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
69. 2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
- 20 70. 2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
71. 2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

72. 2,3-O-Isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
73. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
- 5 74. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
75. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
76. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
- 10 77. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
78. 2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpiperidinyl)- α -L-xylo-2-hexulofuranose
- 15 79. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpiperidinyl)- α -L-xylo-2-hexulofuranose
80. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpiperidinyl)- α -L-xylo-2-hexulofuranose
81. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpiperidinyl)- α -L-xylo-2-hexulofuranose
- 20 82. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpiperidinyl)- α -L-xylo-2-hexulofuranose
83. 2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpiperidinyl)- α -L-xylo-2-hexulofuranose

84. 2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
85. 2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
- 5 86. 2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
87. 2,3-O-Isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
88. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
- 10 89. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
90. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
- 15 91. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
92. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpiperidiny)- α -L-xylo-2-hexulofuranose
93. 2,3-O-Isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
- 20 94. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
95. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose

96. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
97. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
- 5 98. 2,3-O-Isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
99. 2,3-O-Isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
100. 2,3-O-Isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
- 10 101. 2,3-O-Isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
102. 2,3-O-Isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
- 15 103. 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
104. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
- 20 105. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
106. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose
107. 2,3-O-Isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylmorphiliny)- α -L-xylo-2-hexulofuranose

108. 2,3-O-Isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
109. 2,3-O-Isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
- 5 110. 2,3-O-Isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
111. 2,3-O-Isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
112. 2,3-O-Isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose
- 10 113. 2,3-O-Isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
114. 2,3-O-Isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 15 115. 2,3-O-Isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
116. 2,3-O-Isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
117. 2,3-O-Isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose
- 20 118. 2,3-O-Isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
119. 2,3-O-Isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

120. 2,3-O-Isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
121. 2,3-O-Isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
- 5 122. 2,3-O-Isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose
123. 2,3-O-Isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose.

10 The sugar derivatives of the present invention exhibit various pharmacological properties and are useful for treating animals, the term animal as defined herein includes human or mammal, with various inflammatory and autoimmune disorders, such as bronchial asthma, rheumatoid arthritis, type I diabetes, multiple sclerosis, allograft rejection and

15 psoriasis.

The free amino compounds of the present invention are basic and form organic and inorganic acid salts. The resulting salts are useful by themselves and in the therapeutic composition and method of use. These salts may be

20 prepared by the usual prior art techniques, such as suspending the compound in water and then adding one equivalent of the desired organic or mineral acid. Examples of preferred acids include hydrochloric, sulphuric, nitric, maleic, benzoic, tartaric, acetic, p-aminobenzoic, oxalic, succinic and glucuronic acid.

25

The neutral solution of the resulting salt is subjected to rotary evaporation under diminished pressure to the volume necessary to ensure precipitation of the salt upon cooling, which is then filtered and dried. The salts of the present invention may also be prepared strictly under non-
5 aqueous conditions. For example, dissolving the free amine in a suitable organic solvent, adding exactly one equivalent of the desired acid to the same solvent and stirring the solution at 0–5° C causes precipitation of the amine salt, which is then filtered, washed with solvent and dried. The amine salts are often preferred for use in formulating the therapeutic compositions as they are
10 crystalline and relatively more stable and non-hydroscopic. The amine salts are also better adapted for intramuscular injection than are the free amines.

Because of their valuable pharmacological properties, the compounds of the present invention may be administered to an animal for treatment orally,
15 topically, rectally, intranasally or by parenteral route. When the therapeutic composition is to be administered orally, it is preferred that the compounds of the present invention are admixed with a filler and/or binder, such as starch and a disintegrator. The admixture may be pressed into a tablet conveniently sized for oral administration. Capsules may also be filled with the powdered
20 therapeutic composition for oral administration. Alternatively, a water solution of the amine salt or suspension of the therapeutic composition may be admixed with a flavored syrup and administered orally. A salt of the free acid is usually preferred when the compound is administered by parenteral route.

The pharmaceutical compositions of the present invention are preferably produced and administered in dosage units, with each unit containing a certain amount of at least one compound of the invention and/or at least one physiologically acceptable base salt addition thereof. The dosage
5 may be varied over extremely wide limits, as the compounds are effective at low dosage levels and relatively free of toxicity. The compounds may be administered in the low micromolar concentration, which is therapeutically effective, and the dosage may be increased as desired up to the maximum dosage tolerated by the patient.

10

The present invention also includes within its scope prodrugs of the compounds of Formula I. In general, such prodrugs will be functional derivatives of these compounds which are readily converted *in vivo* into the defined compounds. Conventional procedures for the selection and
15 preparation of suitable prodrugs are known.

The present invention also includes the enantiomers, diastereomers, N-oxides, polymorphs and pharmaceutically acceptable salts of these compounds as well as metabolites having the same type of activity. This
20 invention further includes pharmaceutical compositions comprising the molecules of Formula I or prodrugs, metabolite enantiomers, diastereomers, N-oxides, polymorphs or pharmaceutically acceptable salts thereof, in combination with pharmaceutically acceptable carriers and optionally included excipients.

25

The examples mentioned below demonstrate the general synthetic procedure as well as the specific preparation of the preferred compounds. The examples are provided to illustrate the details of the invention and should not be considered to limit the scope of the present invention.

5

EXPERIMENTAL DETAILS

Various solvents, such as acetone, methanol, pyridine, ether, tetrahydrofuran, hexane and dichloromethane, were dried using various drying agents according to the procedure described in the literature. Wet
10 solvents gave poor yields of the products and intermediates. IR spectra were recorded as nujol mulls or a thin neat film on a Perkin Elmer Paragon instrument. Nuclear Magnetic Resonance (NMR) data (H, C) were recorded using a Varian XL-300 MHz instrument using tetramethylsilane as an internal standard. Chemical Ionization Mass Spectra (CIMS) were obtained using a
15 Finnigan MAT-4510 mass spectrometer equipped with an INCOS data system. Generally, a direct exposure probe and methane as the reagent gas (0.33 mmHg, 120° C source temperature) were used.

EXAMPLE 1

20 **Preparation of 2,3-O-isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-hexa-methyleneimino- α -L-xylo-2-hexulofuranose.**

2,3-O-Isopropylidene-1-O-dodecyl-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose (prepared according to the method described in U.S. Pat. No. 5,637,570) (2.0 gm) was dissolved in dry methylene chloride (20 ml).
25 To this solution was added phenyl isocyanate (0.64 gm) dropwise at 0–10° C

and the reaction mixture was stirred at the same temperature for 2 hours. It was then washed with water (2 times 5 ml) and brine (2 times 5 ml). The organic layer was dried and the solvent was removed. The crude product so obtained was purified by column chromatography and eluted with 50% ethylacetate in hexane. Pure product yield: 61%.

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose with a suitable isocyanate:

- 10 2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 15 2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose
- 2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose.

20

EXAMPLE 2

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose.

- 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose (prepared as described in Example 1 by replacing the
- 25

hexamethyleneimino group with pyrrolidine at position 6) (1.9 gm) was dissolved in methylene chloride (20 ml). To this solution was added phenyl isocyanate (0.56 gm) dropwise at 0–10° C and the reaction mixture was stirred at the same temperature for 2 hours. The organic layer was washed
5 with water (2 times 10 ml), followed by saturated solution of sodium chloride (2 times 10 ml), dried over anhydrous sodium sulfate and filtered. The solvent was removed with rotary evaporation. The crude product so obtained was purified by flash chromatography using silica gel and eluted with 30% ethylacetate in hexane. Pure product yield: 53.80% (1.0 gm).

10

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose with a suitable isocyanate:

2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
15

2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

20 2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose.

25

EXAMPLE 3

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose.

2,3-O-Isopropylidene-1-O-dodecyl-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose (prepared as described in Example 1 by replacing the hexamethyleneimino group with the morpholine group at position 6) (2.0 gm) was dissolved in methylene chloride (20 ml). To this solution was added phenyl isocyanate (1.0 ml) dropwise at 0–10° C and the reaction mixture was stirred at the same temperature for 2 hours. The organic layer was washed with water (2 times 10 ml), followed by saturated solution of sodium chloride (2 times 10 ml), dried over anhydrous sodium sulfate and filtered. The solvent was removed with rotary evaporation. The crude product so obtained was purified by flash chromatography using silica gel and eluted with 30% ethylacetate in hexane. Pure product yield: 54.6% (1.20 gm).

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose with a suitable isocyanate:

2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose.

5

EXAMPLE 4

Preparation of 2,3-O-isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose.

2,3-O-Isopropylidene-1-O-dodecyl-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose (prepared as described in Example 1 by replacing the hexamethyleneimino group with the piperidino group at position 6) (2.0 gm) was dissolved in methylene chloride (20 ml). To this solution was added phenyl isocyanate (0.58 gm) dropwise at 0–10° C and the reaction mixture was stirred at the same temperature for 2 hours. The reaction was monitored with thin layer chromatography (TLC). The organic layer was washed with water (2 times 10 ml), followed by saturated solution of sodium chloride (2 times 10 ml), dried over anhydrous sodium sulfate and filtered. The solvent was removed with rotary evaporation. The crude product so obtained was purified by flash chromatography using silica gel and eluted with 30% ethylacetate in hexane. Pure product yield: 35.1% (0.90 gm).

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose with a suitable isocyanate:

2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-piperidinol- α -L-xylo-2-hexulofuranose

5 2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose.

EXAMPLE 5

Preparation of 2,3-O-isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose.

15 2,3-O-Isopropylidene-1-O-dodecyl-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose (prepared as described in Example 1 by replacing the hexamethyleneimino group with the 2-ethylpyrrolidinyl group at position 6) (1.5 gm) was dissolved in methylene chloride (20 ml). To this solution was added phenyl isocyanate (1.0 ml) dropwise at 0–10° C and the reaction
20 mixture was stirred at the same temperature for 2 hours. The reaction was monitored with TLC. The organic layer was washed with water (2 times 10 ml), followed by saturated solution of sodium chloride (2 times 10 ml), dried over anhydrous sodium sulfate and filtered. The solvent was removed with rotary evaporation. The crude product so obtained was purified by flash

chromatography using silica gel and eluted with 30% ethylacetate in hexane.
Pure product yield: 60.2% (1.1 gm).

The following compounds were synthesized similarly by reacting 2,3-O-

5 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose with a suitable isocyanate:

2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

15 2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose.

EXAMPLE 6

Preparation of 2,3-O-isopropylidene-1-O-dodecyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose.

2,3-O-Isopropylidene-1-O-dodecyl-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose (prepared as described in Example 1 by replacing the hexamethyleneimino group with the 2-ethylmorpholino group at position 6) (2.0 gm) was dissolved in methylene chloride (20 ml). To this solution was added phenyl isocyanate (0.56 gm) dropwise at 0–10° C and the reaction

mixture was stirred at the same temperature for 2 hours. The reaction was monitored with TLC. The organic layer was washed with water (2 times 10 ml), followed by saturated solution of sodium chloride (2 times 10 ml), dried over anhydrous sodium sulfate and filtered. The solvent was removed with rotary evaporation. The crude product so obtained was purified by flash chromatography using silica gel and eluted with 30% ethylacetate in hexane. Pure product yield: 30.4% (0.75 gm).

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-dodecyl-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose with a suitable isocyanate:

2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose.

EXAMPLE 7

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose.

This compound was prepared according to method described in Example 2 by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product yield: 58%.

5

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose with the desired isocyanate:

- 2,3-O-isopropylidene-1-O-dodecyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
- 10 2,3-O-isopropylidene-1-O-dodecyl-4-(p-tolylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
- 2,3-O-isopropylidene-1-O-dodecyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
- 15 2,3-O-isopropylidene-1-O-dodecyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose
- 2,3-O-isopropylidene-1-O-dodecyl-4-(methylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose.

20

EXAMPLE 8

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-

morpholinyl- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C.

Pure product yield: 61%.

The following compounds were synthesized similarly by reacting 2,3-O-

5 isopropylidene-1-O-decyl-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose
with the desired isocyanate:

2,3-O-isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-
morpholinyl- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-morpholinyl-
 α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-
morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-
morpholinyl- α -L-xylo-2-hexulofuranose

15 2,3-O-isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-morpholinyl-
 α -L-xylo-2-hexulofuranose.

EXAMPLE 9

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-
20 deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in Example
1 by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-
examethyleneimino- α -L-xylo-2-hexulofuranose with phenyl isocyanate
at 0–10° C. Pure product yield: 69%.

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose with the desired isocyanate:

2,3-O-isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-

5 hexamethyleneimino- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-

hexamethyleneimino- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-

hexamethyleneimino- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-

hexamethyleneimino- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-

hexamethyleneimino- α -L-xylo-2-hexulofuranose.

15

EXAMPLE 10

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product
20 yield: 74%.

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose
25 with the desired isocyanate:

2,3-O-isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

5 2,3-O-isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-1-O-decyl-4-(methylester)-6-deoxy-6-piperidinyl- α -L-xylo-2-hexulofuranose.

EXAMPLE 11

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose.

15 This compound was prepared according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product yield: 74%.

20 The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose with the desired isocyanate:
2,3-O-isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-

ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-

ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

5 2,3-O-isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-

ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-(2-

ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose.

10

EXAMPLE 12

Preparation of 2,3-O-isopropylidene-1-O-decyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-(2-

15 ethylmorpholinyl)- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10°

C. Pure product yield: 72%.

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-decyl-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-

20 hexulofuranose with the desired isocyanate:

2,3-O-isopropylidene-1-O-decyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-

ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-

ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-decyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

5 2,3-O-isopropylidene-1-O-decyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose.

EXAMPLE 13

Preparation of 2,3-O-isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in Example 2 by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product yield: 85.4%

15 The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose with the desired isocyanate:

2,3-O-isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-pyrrolidinyl- α -L-xylo-2-hexulofuranose.

5

EXAMPLE 14

Preparation of 2,3-O-isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in
10 Example 3 by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product yield: 79%.

The following compounds were synthesized similarly by reacting 2,3-O-
15 isopropylidene-1-O-decyl-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose with the desired isocyanate:

2,3-O-isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-morpholinyl-
20 α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-morpholinyl- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-morpholinyl-
 α -L-xylo-2-hexulofuranose.

EXAMPLE 15

5 **Preparation of 2,3-O-Isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose.**

This compound was prepared according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-hexamethylene-imino- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0-
10 10° C. Pure product yield: 91%.

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose with the desired isocyanate:

15 2,3-O-isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose

20 2,3-O-isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-hexamethyleneimino- α -L-xylo-2-hexulofuranose.

EXAMPLE 16

Preparation of 2,3-O-isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose.

This compound was prepared according to the method described in
5 Example 3 by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product yield: 47.6%.

The following compounds were synthesized similarly by reacting 2,3-O-
10 isopropylidene-1-O-heptyl-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose with the desired isocyanate:

2,3-O-isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose

15 2,3-O-isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose

20 2,3-O-isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-piperidiny- α -L-xylo-2-hexulofuranose.

EXAMPLE 17

Preparation of 2,3-O-isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidinyl)- α -L-xylo-2-hexulofuranose.

25

This compound was prepared according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10°

C. Pure product yield: 68%.

5

The following compounds were synthesized similarly by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose with the desired isocyanate:

10 2,3-O-isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose

15 2,3-O-isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylpyrrolidiny)- α -L-xylo-2-hexulofuranose.

20

EXAMPLE 18

Preparation of 2,3-O-isopropylidene-1-O-heptyl-4-(phenylcarbamate)-6-deoxy-6-(2-ethylmorpholiny)- α -L-xylo-2-hexulofuranose.

This compound was prepared similarly according to the method described in Example 3 by reacting 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-

6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose with phenyl isocyanate at 0–10° C. Pure product yield: 75.8%.

The following compounds were synthesized similarly by reacting the

5 2,3-O-isopropylidene-1-O-heptyl-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose with the desired isocyanate:

2,3-O-isopropylidene-1-O-heptyl-4-(p-chlorophenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

10 2,3-O-isopropylidene-1-O-heptyl-4-(p-tolylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-methoxyphenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

2,3-O-isopropylidene-1-O-heptyl-4-(p-nitrophenylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose

15 2,3-O-isopropylidene-1-O-heptyl-4-(methylcarbamate)-6-deoxy-6-(2-ethylmorpholinyl)- α -L-xylo-2-hexulofuranose.

While the present invention has been described in terms of its specific embodiments, certain modifications and equivalents will be apparent to those skilled in the art and are intended to be included within the scope of this invention, which is to be limited only by the scope of the appended claims.